<u>What is Claimed Is</u>:

1. A multiple layer structure, comprising a pair of spaced-apart crystalline layers of different materials with an intermediate crystalline layer between and in contact with each of said pair of crystalline layers, said intermediate crystalline layer providing one of said crystalline layers of said pair with a stronger out-of-plane preferred growth orientation than if each of said pair of crystalline layers are in overlying contact.

2. The multiple layer structure as in claim 1, comprising, in overlying, contacting sequence:

(a) a first crystalline layer of a material having a first crystal structure, a first preferred growth orientation and a first, closest packed plane, nearest neighbor atomic spacing;

(b) a said intermediate layer in the form of a second crystalline layer of a material having a second crystal structure, a second preferred growth orientation, and a second, closest packed plane, nearest neighbor atomic spacing; and

(c) a third crystalline layer of a material having a third crystal structure, a third preferred growth orientation, and a third closest packed plane, nearest neighbor atomic spacing, wherein:

(1) said first and said third crystal structures are different;

(2) said first and said third closest packed plane, nearest neighbor atomic spacings are different;

(3) said second crystal structure is of the same type as one of said first and said third crystal structures; and

(4) the atomic spacing mismatch between said second closest packed plane, nearest neighbor atomic spacing of said second crystalline layer and the closest packed plane, nearest neighbor atomic spacing of one of said first and third crystalline layers having a crystal structure different

from that of said second crystalline layer is less than the mismatch between the closest packed plane, nearest neighbor atomic spacings of said first and third crystalline layers, whereby:

said third crystalline layer in overlying contact with said second crystalline layer has a stronger preferred out-of-plane growth orientation than if said third crystalline layer is in overlying contact with said first crystalline layer.

3. The multiple layer structure as in claim 2, wherein:

said third crystalline layer in overlying contact with said second crystalline layer has a stronger preferred hexagonal close-packed (*hcp*) <0002> or face-centered cubic (*fcc*) <111> out-of-plane growth orientation than if said third crystalline layer is in overlying contact with said first crystalline layer.

4. The multi-layer structure as in claim 3, wherein:

said first crystalline layer comprises a first *fcc* material having a <111> preferred growth orientation and a first {111} lattice parameter;

said second crystalline layer comprises a second *fcc* material having a <111> preferred growth orientation and a second {111} lattice parameter different from said first {111} lattice parameter; and

said third crystalline layer comprises an *hcp* material having a <0002> preferred growth orientation and a {0002} lattice parameter more closely matched to said second {111} lattice parameter than to said first {111} lattice parameter.

5. The multi-layer structure as in claim 4, wherein:

said first crystalline layer is from about 1 to about 1,000 nm thick and comprised of a first *fcc* material selected from the group consisting of: Ag, Cu, Au, Ni, Pt, Pd, Al, Rh, Ir, Pb, Ca, Sr, Yb, and alloys based thereon;

said second crystalline layer is from about 1 to about 50 nm thick and comprised of a second *fcc* material selected from the group consisting of: Ag, Cu, Au, Ni, Pt, Pd, Al, Rh, Ir, Pb, Ca, Sr, Yb, and alloys based thereon; and

said third crystalline layer is from about 1 to about 50 nm thick and comprised of an *hcp* material selected from the group consisting of: Ru, Ti, Co, Re, Be, Mg, Sc, Zn, Se, Zr, Cd, Te, La, Hf, Os, Tl, Pr, Nd, Gd, Tb, Dy, Ho, Er, Tm, Lu, Y, and alloys based thereon.

6. The multiple layer structure as in claim 3, wherein:

said first crystalline layer comprises an *fcc* material having a <111> preferred growth orientation and a {111} lattice parameter;

said second crystalline layer comprises a first *hcp* material having a <0002> preferred growth orientation and a first {0002} lattice parameter substantially matched to said {111} lattice parameter; and

said third crystalline layer comprises a second *hcp* material having a <0002> preferred growth orientation and a second {0002} lattice parameter different from said first {0002} lattice parameter.

7. The multiple layer structure as in claim 6, wherein:

said first crystalline layer is from about 1 to about 1,000 nm thick and comprised of an *fcc* material selected from the group consisting of: Ag, Cu, Au, Ni, Pt, Pd, Al, Rh, Ir, Pb, Ca, Sr, Yb, and alloys based thereon;

said second crystalline layer is from about 1 to about 50 nm thick and comprised of a first *hcp* material selected from the group consisting of: Ru, Ti, Co, Re, Be, Mg, Sc, Zn, Se, Zr, Cd, Te, La, Hf, Os, Tl, Pr, Nd, Gd, Tb, Dy, Ho, Er, Tm, Lu, and alloys based thereon; and

said third crystalline layer is from about 1 to about 50 nm thick and comprised of a second *hcp* material selected from the group consisting of: CoCrPt alloys or from the group consisting of: Ru, Ti, Co, Re, Be, Mg, Sc, Zn, Se, Zr, Cd, Te, La, Hf, Os, Tl, Pr, Nd, Gd, Tb, Dy, Ho, Er, Tm, Lu, Y, and alloys based thereon.

8. The multiple layer structure as in claim 3, wherein:

said first crystalline layer comprises an *hcp* material having a <0002> preferred growth orientation and a {0002} lattice parameter;

said third crystalline layer comprises a first *fcc* material having a <111> preferred growth orientation and a second {111} lattice parameter different from said first {111} lattice parameter; and

said second crystalline layer comprises a second *fcc* material having a <111> preferred growth orientation and a second {111} lattice parameter more closely matched to said {0002} lattice parameter than to said first {111} lattice parameter.

9. The multiple layer structure as in claim 8, wherein:

said first crystalline layer is from about 1 to about 1,000 nm thick and comprised of an *hcp* material selected from the group consisting of: Ru, Ti, Co, Re, Be, Mg, Sc, Zn, Se, Zr, Cd, Te, La, Hf, Os, Tl, Pr, Nd, Gd, Tb, Dy, Ho, Er, Tm, Lu, Y, and alloys based thereon;

said second crystalline layer is from about 1 to about 50 nm thick and comprised of a first *fcc* material selected from the group consisting of: Ag, Cu, Au, Ni, Pt, Pd, Al, Rh, Ir, Pb, Ca, Sr, Yb, and alloys based thereon; and

said third crystalline layer is from about 1 to about 50 nm thick and comprised of a second *fcc* material selected from the group consisting of: Ag, Cu, Au, Ni, Pt, Pd, Al, Rh, Ir, Pb, Ca, Sr, Yb, and alloys based thereon.

10. The multiple layer structure as in claim 3, wherein:

said first crystalline layer comprises a first *hcp* material having a <0002> preferred growth orientation and a first {0002} lattice parameter;

said second crystalline layer comprises a second *hcp* material having a <0002> preferred growth orientation and a second {0002} lattice parameter different from said first {0002} lattice parameter; and

said third crystalline layer comprises an *fcc* material having a <111> preferred growth orientation and a {111} lattice parameter more closely matched to said second {0002} lattice parameter than to said first {0002} lattice parameter.

11. The multiple layer structure as in claim 10, wherein:

said first crystalline layer is from about 1 to about 1,000 nm thick and comprised of a first *hcp* material selected from the group consisting of: Ru, Ti, Co, Re, Be, Mg, Sc, Zn, Se, Zr, Cd, Te, La, Hf, Os, Tl, Pr, Nd, Gd, Tb, Dy, Ho, Er, Tm, Lu, Y, and alloys based thereon;

said second crystalline layer is from about 1 to about 50 nm thick and comprised of a second *hcp* material selected from the group consisting of: Ru, Ti, Co, Re, Be, Mg, Sc, Zn, Se, Zr, Cd, Te, La, Hf, Os, Tl, Pr, Nd, Gd, Tb, Dy, Ho, Er, Tm, Lu, Y, and alloys based thereon; and

said third crystalline layer is from about 1 to about 50 nm thick and comprised of an *fcc* material selected from the group consisting of: Ag, Cu, Au, Ni, Pt, Pd, Al, Rh, Ir, Pb, Ca, Sr, Yb, and alloys based thereon.

12. A perpendicular magnetic recording medium, comprising the multiple layer structure of claim 3 and a perpendicular magnetic recording layer comprising a magnetic material with a strong preferred *hcp* <0002> or *fcc* <111> out-of-plane growth orientation in overlying contact with said one layer of said pair of layers having said strong preferred *hcp* <0002> or *fcc* <111> out-of-plane growth orientation.

13. The perpendicular magnetic recording medium as in claim 13, wherein:

said perpendicular magnetic recording layer comprises at least one magnetic material with a strong *hcp* <0002> out-of-plane growth orientation, selected from the group consisting of: Co-based alloys, CoCrPt(SiO_2), other CoPtO-containing alloys, CoCrPtB, other CoCrPt-containing alloys, and other

ordered or disordered Co-based alloys, or at least one magnetic material with a strong *fcc* <111> out-of-plane growth orientation, selected from the group consisting of a multi-layer superlattice structure including a bi-layer comprising a Co-based alloy layer and a layer including at least one of Pt and Pd, a multi-layer superlattice structure including a bi-layer comprising an Fe-based alloy layer and a layer including at least one of Pt and Pd, and an L_{10} structure selected from FePt, CoPt, FePd, and CoPd materials with and without at least one alloying element.

14. A perpendicular magnetic recording medium, comprising:

(a) a non-magnetic substrate having a surface;

(b) a layer stack formed over said substrate surface, said layer stack comprising, in overlying sequence from said substrate surface:

(i) a magnetically soft underlayer;

(ii) a multiple layer interlayer structure for strengthening a preferred out-of-plane growth orientation of a layer of a perpendicular magnetic recording material formed thereon; and

(iii) a perpendicular magnetic recording layer having a strong preferred *hcp* <0002> or *fcc* <111> out-of-plane growth orientation;

wherein said multiple layer interlayer structure comprises, in overlying, contacting sequence from a surface of said magnetically soft underlayer:

(1) a first crystalline layer of a material having a first crystal structure, a first preferred growth orientation and a first, closest packed plane, nearest neighbor atomic spacing;

(2) a said intermediate layer in the form of a second crystalline layer of a material having a second crystal structure, a second preferred growth orientation, and a second, closest packed plane, nearest neighbor atomic spacing; and

(3) a third crystalline layer of a material having a third crystal structure, a third preferred growth orientation, and a third closest packed plane, nearest neighbor atomic spacing, wherein:

(I) said first and said third crystal structures are different;

(II) said first and said third closest packed plane, nearest neighbor atomic spacings are different;

(III) said second crystal structure is of the same type as one of said first and said third crystal structures; and

(IV) the atomic spacing mismatch between said second closest packed plane, nearest neighbor atomic spacing of said second crystalline layer and the closest packed plane, nearest neighbor atomic spacing of one of said first and third crystalline layers having a crystal structure different from that of said second crystalline layer is less than the mismatch between the closest packed plane, nearest neighbor atomic spacings of said first and third crystalline layers, whereby:

said third crystalline layer in overlying contact with said second crystalline layer has a stronger preferred out-of-plane growth orientation than if said third crystalline layer is in overlying contact with said first crystalline layer.

15. The recording medium as in claim 14, wherein:

said third crystalline layer in overlying contact with said second crystalline layer has a stronger preferred hexagonal close-packed (*hcp*) <0002> or face-centered cubic (*fcc*) <111> out-of-plane growth orientation than if said third crystalline layer is in overlying contact with said first crystalline layer.

16. The recording medium as in claim 15, wherein:

said first crystalline layer comprises a first *fcc* material having a <111> preferred growth orientation and a first {111} lattice parameter;

said second crystalline layer comprises a second *fcc* material having a <111> preferred growth orientation and a second {111} lattice parameter different from said first {111} lattice parameter; and

said third crystalline layer comprises an *hcp* material having a <0002> preferred growth orientation and a {0002} lattice parameter more closely matched to said second {111} lattice parameter than to said first {111} lattice parameter.

17. The recording medium as in claim 16, wherein:

said first crystalline layer is from about 1 to about 1,000 nm thick and comprised of a first *fcc* material selected from the group consisting of: Ag, Cu, Au, Ni, Pt, Pd, Al, Rh, Ir, Pb, Ca, Sr, Yb, and alloys based thereon;

said second crystalline layer is from about 1 to about 50 nm thick and comprised of a second *fcc* material selected from the group consisting of: Ag, Cu, Au, Ni, Pt, Pd, Al, Rh, Ir, Pb, Ca, Sr, Yb, and alloys based thereon; and

said third crystalline layer is from about 1 to about 50 nm thick and comprised of an *hcp* material selected from the group consisting of: Ru, Ti, Co, Re, Be, Mg, Sc, Zn, Se, Zr, Cd, Te, La, Hf, Os, Tl, Pr, Nd, Gd, Tb, Dy, Ho, Er, Tm, Lu, Y, and alloys based thereon.

18. The recording medium as in claim 15, wherein:

said first crystalline layer comprises an *fcc* material having a <111> preferred growth orientation and a {111} lattice parameter;

said second crystalline layer comprises a first *hcp* material having a <0002> preferred growth orientation and a first {0002} lattice parameter substantially matched to said {111} lattice parameter; and

said third crystalline layer comprises a second *hcp* material having a <0002> preferred growth orientation and a second {0002} lattice parameter different from said first {0002} lattice parameter.

19. The recording medium as in claim 18, wherein:

said first crystalline layer is from about 1 to about 1,000 nm thick and comprised of an *fcc* material selected from the group consisting of: Ag, Cu, Au, Ni, Pt, Pd, Al, Rh, Ir, Pb, Ca, Sr, Yb, and alloys based thereon;

said second crystalline layer is from about 1 to about 50 nm thick and comprised of a first *hcp* material selected from the group consisting of: Ru, Ti, Co, Re, Be, Mg, Sc, Zn, Se, Zr, Cd, Te, La, Hf, Os, Tl, Pr, Nd, Gd, Tb, Dy, Ho, Er, Tm, Lu, and alloys based thereon; and

said third crystalline layer is from about 1 to about 50 nm thick and comprised of a second *hcp* material selected from the group consisting of: CoCrPt alloys or from the group consisting of: Ru, Ti, Co, Re, Be, Mg, Sc, Zn, Se, Zr, Cd, Te, La, Hf, Os, Tl, Pr, Nd, Gd, Tb, Dy, Ho, Er, Tm, Lu, Y, and alloys based thereon.

20. The recording medium as in claim 15, wherein:

said first crystalline layer comprises an *hcp* material having a <0002> preferred growth orientation and a {0002} lattice parameter;

said third crystalline layer comprises a first *fcc* material having a <111> preferred growth orientation and a second {111} lattice parameter different from said first {111} lattice parameter; and

said second crystalline layer comprises a second *fcc* material having a <111> preferred growth orientation and a second {111} lattice parameter more closely matched to said {0002} lattice parameter than to said first {111} lattice parameter.

21. The recording medium as in claim 20, wherein:

said first crystalline layer is from about 1 to about 1,000 nm thick and comprised of an *hcp* material selected from the group consisting of: Ru, Ti, Co, Re, Be, Mg, Sc, Zn, Se, Zr, Cd, Te, La, Hf, Os, Tl, Pr, Nd, Gd, Tb, Dy, Ho, Er,

Tm, Lu, Y, and alloys based thereon;

said second crystalline layer is from about 1 to about 50 nm thick and comprised of a first *fcc* material selected from the group consisting of: Ag, Cu, Au, Ni, Pt, Pd, Al, Rh, Ir, Pb, Ca, Sr, Yb, and alloys based thereon; and

said third crystalline layer is from about 1 to about 50 nm thick and comprised of a second *fcc* material selected from the group consisting of: Ag, Cu, Au, Ni, Pt, Pd, Al, Rh, Ir, Pb, Ca, Sr, Yb, and alloys based thereon.

22. The recording medium as in claim 15, wherein:

said first crystalline layer comprises a first *hcp* material having a <0002> preferred growth orientation and a first {0002} lattice parameter;

said second crystalline layer comprises a second *hcp* material having a <0002> preferred growth orientation and a second [0002} lattice parameter different said first {0002} lattice parameter; and

said third crystalline layer comprises an *fcc* material having a <111> preferred growth orientation and a {111} lattice parameter substantially matched to said second {0002} lattice parameter.

23. The recording medium as in claim 22, wherein:

said first crystalline layer is from about 1 to about 1,000 nm thick and comprised of a first *hcp* material selected from the group consisting of: Ru, Ti, Co, Re, Be, Mg, Sc, Zn, Se, Zr, Cd, Te, La, Hf, Os, Tl, Pr, Nd, Gd, Tb, Dy, Ho, Er, Tm, Lu, Y, and alloys based thereon;

said second crystalline layer is from about 1 to about 50 nm thick and comprised of a second *hcp* material selected from the group consisting of: Ru, Ti, Co, Re, Be, Mg, Sc, Zn, Se, Zr, Cd, Te, La, Hf, Os, Tl, Pr, Nd, Gd, Tb, Dy, Ho, Er, Tm, Lu, Y, and alloys based thereon; and

said third crystalline layer is from about 1 to about 50 nm thick and comprised of an *fcc* material selected from the group consisting of: Ag, Cu, Au, Ni, Pt, Pd, Al, Rh, Ir, Pb, Ca, Sr, Yb, and alloys based thereon.

24. The recording medium as in claim 15, wherein:

said non-magnetic substrate comprises at least one material selected from the group consisting of Al, NiP-plated Al, Al-Mg alloys, other Al-based alloys, other non-magnetic metals, other non-magnetic alloys, glass, ceramics, polymers, glass-ceramics, and composites and/or laminates thereof;

said magnetically soft underlayer comprises at least one material selected from the group consisting of Fe-based alloys, Co-based alloys, and Ni-based alloys; and

said perpendicular magnetic recording layer comprises at least one magnetic material with a strong *hcp* <0002> out-of-plane growth orientation, selected from the group consisting of: Co-based alloys, CoCrPt(SiO_2), other CoPtO-containing alloys, CoCrPtB, other CoCrPt-containing alloys, and other ordered or disordered Co-based alloys, or at least one magnetic material with a strong *fcc* <111> out-of-plane growth orientation, selected from the group consisting of a multi-layer superlattice structure including a bi-layer comprising a Co-based alloy layer and a layer including at least one of Pt and Pd, a multi-layer superlattice structure including a bi-layer comprising an Fe-based alloy layer and a layer including at least one of Pt and Pd, and an L_{10} structure selected from FePt, CoPt, FePd, and CoPd materials with and without at least one alloying element.